Vertical Technology Alliances: The Impact of Technological Depth and Breadth on Alliance Governance Structure

Mohammad Saleh Farazi[1], Shanthi Gopalakrishnan[2], Ana Perez-Luño[1]
[1]Department of Business Organization and Marketing, Universidad Pablo de Olavide, Seville, Spain
[2]School of Management, New Jersey Institute of Technology, University Heights Newark, New Jersey, United States

***Abstract*--New high-tech firms have extensively used strategic alliances with large incumbent partners to access complimentary resources and capabilities and to finance their technology projects. However, due to their initially weak bargaining position, they tend to relinquish a disproportional amount of control rights to the larger firm that finances the R&D alliance. This raises the question: How can new high-tech firms, e.g. biotech firms, leverage their knowledge resources to retain control in alliance with larger partners, e.g. pharmaceutical incumbent firms? And, does alliance experience add to their leverage? Focusing on equity and non-equity types of alliance governance, we examine how the firm's depth and breadth of technological knowledge resources impact the choice of governance structure. Our findings suggest that high-tech firms with deeper technological resources are better able to retain control when allying with the larger firm. The relationship is stronger when the new firm has more alliance experience.**

I. INTRODUCTION

Broadly speaking, alliance governance involves choosing between equity and non-equity forms, also referred to as quasi-hierarchies and quasi-markets, respectively ([13]; [26]). Prior research has described differences in alliance governance structures as being similar to the differences between markets and hierarchies [14]. Non-equity alliances are similar to market transactions with less contractual complexity, as they include contractual arrangements without equity exchange. Equity relationships, on the other hand, are similar to more hierarchical forms of governance, as they include joint ventures and minority equity alliances [14].

As predicted by [2] and empirically supported by [19] and [20], financially constrained firms tend to give up too much ownership of the innovation when entering an alliance. A clear example is when new technology ventures that seek financial capital for their R&D projects, e.g biotech firms with drug discovery and development projects, ally with large incumbents, e.g. established pharmaceutical companies. Reference [19] finds that early stage projects, where there exists lots of information asymmetry among partners, are where the most rights are given up. However, despite being smaller, biotech firms possessing valuable knowledge resources can still have bargaining power in alliance negotiations with larger pharma partners. It is known that larger pharmaceuticals ally with smaller biotech firms in order to access those technological resources that they lack or can't cost-efficiently build internally. These technological resources may also be the main source of competitive advantage for the smaller biotechnology firms and serve as their key source of leverage when allying with a resource-rich pharmaceutical company [9]. The importance of knowledge and technological resources in science-based firms such as biotechnology firms is so much that many scholars have described them as being driven by scientific discoveries and innovative performance and not merely by regular profit-seeking [16].

Biotech firms vary considerably in terms of their technical capital and stage of technology, and this impacts how the biotech partner exerts its influence in the alliance. If the biotech firms possess valuable R&D capabilities as indicated by the scientific quality of their technological resources, they are less likely to be forced by the alliance partner to give up equity rights [9]. Past research also indicates that new technology firms use their scientific resources to bargain for additional financial capital from their partners at the time of forming vertical technology alliances [8]. Scholars have also found that the characteristics of knowledge involved in the alliance relationship have the highest impact on choice of governance structure (e.g. [5], [27]). However, little empirical research has been carried out to examine whether technologically-specialized or technologically-diversified firms differ in their ability to leverage their technology resources and exert their influence when allying with a larger firm.

In this paper we focus on the focal biotechnology firms and the alliances that they form with established, typically larger pharmaceutical firms, which operate downstream to their activities. We first argue that there must be a link between knowledge structuration (i.e. depth and breadth of technological knowledge) in the biotech firm and its success in attracting desirable downstream partnerships. By "breadth" we refer to the technological diversity or the scope of technological activities, while by "depth" we refer to the accumulated expertise in a single technology area. Then, building on previous research we empirically test the extent to which knowledge structuration affects the degree of control that the biotech firm manages to retain in downstream alliances. Moreover, we argue that prior alliance experience of the biotech firm combines with the structuration of its knowledge resources to affect alliance governance structure.

The aim of this study is to analyze how managers of biotech firms are faced with two different challenges: They need to decide on going for "deeper" or "broader" knowledge base when strategically planning their scientific activities. Upon forming an alliance with a larger pharma firm, they might also be faced with the choice of giving up equity or ownership control in order to gain access to needed resources

or partners capabilities; or the question of how to leverage their own resources to allow their partner less involvement in the form of a non-equity arrangement. This leads to the research question that we address: How do depth and breadth of the technological resources of the biotech firm affect the alliance governance structure?

Our study contributes to the literature on strategy and technology management by examining how the strategic choice regarding depth and breadth of a technology firm's knowledge base relates to the outcome of its alliance governance negotiations. In a study of generic knowledge strategic in the US pharmaceutical industry, [4] found that pharma firms with broader (and shallower) knowledge base were less profitable. We believe our study can bring similar strategy implications and contribute to the literature on technology management by finding which technology firms, as to the stucturation of their technological resources and their alliance experience, were more successful in maintaining control in their alliances.

It is commonly believed that in most biotech-pharma alliances, the big pharma partner chooses among many potential biotech partners [22]. Nevertheless, there is also evidence that biotechnology firms with partners significantly larger than themselves can still have bargaining power to get their interests met when the two parties have opposing governance interests [9]. Therefore, although the objectives and insights of both partners are important, in this study we focus on the biotech firm's resources and its perspective of alliance governance as it often has sufficient influence and decision-making power in the negotiation process.

The rest of this paper proceeds as follows: In section 2, we present the theoretical background that led us to develop our hypotheses. In section 3 we discuss the research methods so that in sections 4 we can empirically test the hypotheses and present the results. Section 5 concludes this study by discussing its findings as well as its limitations and future lines of research.

II. THEORETICAL BACKGROUND & HYPOTHESES DEVELOPMENT

As attested by [11] "A knowledge-based theory of the firm is used to identify circumstances in which collaboration between firms is superior to either market or hierarchical governance in efficiently utilizing and integrating specialized knowledge". Extending this notion to the choice of alliance governance structure (quasi-market or quasi hierarchy), our study adopts a KBV approach to examine which structure is preferred for governing an inter-firm collaboration.

A. Hypothesis Development

In our setting, we believe that biotech firms use their knowledge-based resources to bargain for giving away less control to their pharma partner, and that those biotech firms with many previous alliances leverage their resources more effectively than those without

Figure 1 divides biotech firms into four groups based on their knowledge strategy emphasis: 1) 'Deep Ocean' firms are those which are both broad and deep in their technological resources. These firms have developed their technological expertise in a wide and diversified range of areas, while they are also specialized in each of those technology classes, when compared to other firms. 2) 'Gorge' firms possess a knowledge base which is deep but not broad, in comparison to other firms in the marketplace. Being deep but lacking breadth makes these firms resemble to a gorge. 3) 'Lagoon' firms, on the other hand, have developed their technological resources over a broad range of areas, but are not deeply specialized in any of them, when compared to their competitors. They are thus similar to a lagoon which is known primarily for being broad rather than being deep. 4) Finally, 'Pond' firms are those biotech firms which are nor deep neither broad in their technological resources.

We expect that 'Pond' firms can enter into alliances with larger pharma firms only if they give up control and ownership of the technology in alliance. On the other hand, we expect that 'Deep Ocean' firms are such resource-rich biotech firms that they rarely need alliances with larger pharma firms. They are probably large enough to have managed developing such broad and deep knowledge bases, or perhaps they would obtain financing from venture capitalists and other sources. We therefore expect to see more alliance activity in 'Lagoon' and 'Gorge' groups and we seek to find out if alliance governance differs in the two groups. However, to be more comprehensive, we formulate our hypotheses considering all four groups. We later discuss different findings in each of the groups individually.

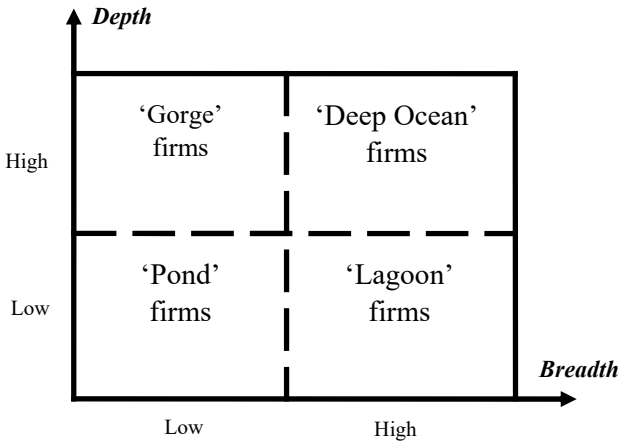

Figure 1: Biotech firms divided into four groups depending on the depth and the breadth of their technological resources

1) Technological Depth and Alliance Governance Structure

Small firms typically prefer less hierarchical governance modes from fear of losing their autonomy, while, based on RBV, large firms prefer more hierarchical alliances to have the exploitation power over the resources but also the final outcome of the collaborative process [28]. Although in need for resources from the pharmaceutical partner, the smaller

biotechnology firm might still want to keep its ownership and thus resist on giving away equity shares to the pharma partner, in order to appropriate more possible profits from its under-developed technology if and once successfully commercialized. Empirical research has found that quasi-market, i.e. non-equity based, structure for alliances are preferred by firms that expect the future value of the alliance to be high, and face high endogenous uncertainty as a result of a competitive relationship with the partner [28].

With limited resources, it is usually best to focus on specific domains of knowledge (core competencies) so that you can become leaders in those areas [4]. Reference [17] demonstrated the strategic importance of developing core products and a deep knowledge base in few critical areas. Many of the biopharma alliances are based on very specific therapeutic areas and the pharma partner often seeks access to a specific technology, drug target or group of potential drugs [9]. We can therefore expect that biotech firms with deeper technological resources would seem more appealing to a potential pharma partner, as being technologically deep is a sign of focusing limited resources on specific domains of excellence.

A possible downside of partnering technologically deep firms could be the fact that scientists of the client firm may have problem assimilating knowledge if it is too specialized, and there might be problems in communication and knowledge transfer between the two partners [15]. However in the case of biotech-pharma alliances, the primary motive of the two partners to enter into alliance is not to 'acquire' knowledge capabilities from the other partner, but to 'access' complimentary capabilities required to finalize the development of product candidates ([12]; [15]). Therefore pharma firms do not face such difficulties when partnering Gorge firms, i.e, firms that are rather deep than broad in their technological resources.

Established pharmaceutical firms typically have a broad knowledge base and are not specialized on a particular set of technology and products [34]. This can lead them to find the specialized knowledge of their biotech partner as valuable. That is to say, the expected future value of a technology under development in a Gorge biotech firm can be perceived as high [28], since accumulated expertise implies that the biotech firm has focused its limited resources on excelling in one or few particular areas. Specialized knowledge from a Gorge biotech firm is particularly sought after, giving the firm more bargaining power and ability to exploit its leverage to give away less control to the pharma partner. This leads to hypothesis 1:

Hypothesis 1: *The deeper the technological resources of the biotech firm, the less likely it is to give up equity to the larger pharma partner when forming an alliance.*

2) Technological Breadth and Alliance Governance Structure

In order to benefit from allying with considerably large and experienced pharma firms, biotech firms must counteract the risk that their partners exploit their negotiating power at the expense of the biotech firm [15]. Firms with limited resources cannot simultaneously expand the depth and the scope of their knowledge (i.e., increase investment in knowledge-based resources while also increasing the diversity of the firm's technology areas) [23].

With a broad knowledge base, the firm is in a better position to combine related technologies in a more complex manner, and is more flexible and adaptable in response to changing environment [4]. The strategic alliance literature has provided empirical evidence for the value of a broad knowledge base in alliance formation. Researchers have found that established, multi-technology, R&D-intense firms are very capable of absorbing new knowledge generated outside firm boundaries. The development of advanced biopharmaceutical products requires knowledge in several disciplines [34]. If the biotech firm has technological resources that are not broad enough, it will only be able to cover a few and initial steps of the product's value chain.

However, being technologically broad, especially in our setting of biotech-pharma alliances, has downsides too. Although with a broad knowledge base the firm can respond in a more flexible way to various technological requirements, the cost of coordination and management of knowledge in a typically small research-intensive biotech firm must not be neglected. If the biotech firm is technologically-broad, chances are higher that its potential pharma partner has expertise in one or several technology areas and is able to form an early-stage alliance, where the technology in question is not significantly advanced. Moreover, when allying a Lagoon type of biotech firm, the client (pharma) partner has a difficult time assessing the eventual market value of the new technology, as only time and continuous development in one or few areas seems to resolve such uncertainty [23]. Thus, the pharma partner insists on taking equity stake in the smaller biotech firm, in order to mitigate possible information asymmetry and opportunism.

The Lagoon type biotech firm, however, has less fear over opportunistic behavior from the pharma side, as opposed to a Gorge biotech firm, as the former has diversified its knowledge base over a broad range of areas and is less concerned over relinquishing control in an alliance that concerns only a few of its areas of expertise. In addition, Lagoon biotech firms are probably interested to first protect their current resources and then to acquire new competencies through learning and adding to their depth in one or few areas. They recognize that they need more cash to do subsequent research in their current areas of expertise. Therefore, they might be willing to give away equity in exchange for financial capital

A biotech firm that is technologically broad, rather than deep, signals the pharma partner that despite limited resources, it has not focused on few technology areas. That is contrary to what a pharma firm would expect from its partner, which is bringing 'depth' to complement its already broad knowledge base. The Lagoon biotech firm has thus, less leverage than the Gorge one to keep its ownership:

Hypothesis 2: *The broader the technological resources of the biotech firm, the more likely it is to give up equity to the larger pharma partner when forming an alliance.*

3) Prior Alliance Experience as a Moderator of Depth-Governance and Breadth-Governance Relationships

Alliances are often viewed (from resource-based and organizational learning perspectives) as vehicles to acquire knowledge and learn new skills and the experience gained from prior collaboration may influence subsequent strategic decisions [24]. By gaining more alliance experience, firms accumulate the capability to benefit from the interdependencies across diverse collaborative behaviors [29].

Biotechnology firms that have greater alliance experience learn to better negotiate and manage alliances with diverse partners [21]. Considering that learning happens in a continuous and iterative fashion where the firm draws from previous experiences and relates them to current activities, biotech firms can use their prior alliance experience and reputation in the alliance social network [1] to bargain on the contract terms with their pharmaceutical partner. Previous alliance experience also means that the biotechnology firm may have begun to institutionalize the alliance experience with a more formalized process, improving intra-organizational and inter-organizational routines and coordination [18].

Moreover, a biotech firm's prior alliance experience is a sign of its reliability and credibility [13] and it also signals its access to other actors in the industry [3]. The bargaining power of the biotechnology firm in alliance negotiations therefore increases, in accordance with its alliance experience. Biotechnology firms may opt to leverage their credibility by keeping a full ownership position through the formation of non-equity alliances. Reference [9] found that biotechnology firms that had past ties to influential clients in the marketplace were likely to have less contractual complexity in their subsequent alliances, as these past ties lead to greater trust between partners and fewer contractual provisions. If a firm enjoys a positive reputation as an alliance partner, then future potential partners may be more willing to trust the firm and enter into a non-equity agreement.

As we argued before reaching to hypothesis 1, Gorge biotech firms leverage the depth of their technological resources as it is a sign of accumulated expertise over time. A Gorge firm with more alliance experience, enjoys a reputation for two reasons: First, being technologically focused and well developed during time, and second, having had prior alliances which implies credibility and reliability. A Gorge biotech firm, based on the above, gains even more bargaining power as it builds up more alliance experience. This leads to hypotheses 3a:

Hypothesis 3a: *The negative relationship between depth of the technological resources of the biotech firm and the use of equity governance structure in alliance with pharma firms is <u>stronger</u> when the biotech firm has more prior alliance experience.*

Prior alliance experience, even in the case of a technologically broad firm, implies that it has gained collaborative know-how: The ability to develop specialized knowledge and institutionalize routines as a result of previous experiences [31]. Generally speaking, collaborative know-how affects the ability of firms, engaged in strategic alliances, to understand and adopt proper procedures and mechanisms for knowledge accumulation, transfer, interpretation, and diffusion – and ultimately learning and innovation [25].

Similar to what happens to a Gorge firm when it gains more alliance experience, a Lagoon biotech firm that was initially willing to give away control in its alliances, adds to its technological resources as it acquires more alliance experience and leverages its credibility while negotiating alliance terms. This means it will depart from equity type of governance to non-equity, where it can keep more control over the technology in alliance:

Hypothesis 3b: *The positive relationship between breadth of the technological resources of the biotech firm and the use of equity governance structure in alliance with pharma firms is <u>weaker</u> when the biotech firm has more prior alliance experience.*

III. RESEARCH METHODS

A. Research Design and Sample

To test the hypotheses of this study we extracted and combined secondary data from three different sources: Recombinant Capital (ReCap) for alliance data, Derwent Innovation Index for information on patents and their underlying technology classes; and Compustat for firms' financial information. Our sample comprises 390 alliances formed in the period 1995-2000 in the United States, typically by a biotechnology firm as the technology provider and a larger pharmaceutical firm as the technology client.

In biopharma industry, patents play a central role in a firm's strategy as biotechnology appears to be a vital competence for innovation in drug development [34]. Since a patent typically includes a description of a technical problem and a solution to that problem [33], patent data provide a consistent chronology of firms' knowledge accumulation [30].

We constructed measures of depth and breadth of technological resources using information from the patents each biotech firm holds, as available in Derwent Innovation Index. As we are concerned with the technological resources of the biotechnology firm leading up to the alliance, we count the number of patents in a three-year period: the two years leading up to and the year of the alliance. We also record the number of those patents which fall in a given technology class or subject area. We later explain in section 3.2 how these numbers are used to build measures of depth and breadth.

For alliance-level information, we used the ReCap database (Recombinant Capital), which tracks the alliances of US and non-US based firms in the biotechnology and pharmaceutical industries. This database consists of published company information submitted and reviewed by the Securities and Exchange Commission. Finally, we used Compustat database to extract all relevant firm-level financial data of the partnering firms, such as their total assets and profitability in the years leading up to the alliance formation.

We selected the years 1995-2000 for two reasons: At the end of the year 2000, US federal funding increased significantly for biotech research, and hence, biotech firms had greater opportunities to gain funds from the government starting from 2001. However before this date, they were more reliant on financial capital from other industrial firms. With respect to data prior to the year 1995, alliance specific data for biotech firms within the ReCap database were not available for alliances formed prior to 1995.

B. Measures

Dependent Variable: Alliance governance structure $Gov(E, NE)$ is the dependent variable of our study. We categorized all alliances in our sample as non-equity (NE coded as 0) or equity (E coded as 1) alliances ([14]). There were a total of 296 non-equity alliances and 94 equity alliances in the study sample.

It is important to clarify that, although equity-based relationships include both minority equity and joint venture agreements, but we exclude the latter form of partnership from our study. This is because joint ventures create a new organizational entity in a mutual hostage arrangement that implies unique governance dynamics regarding the longevity of the relationship and intertwining of resources [4]. We therefor focus on two broad categories of alliance structures: equity, excluding joint ventures, and non-equity.

Independent Variables: Technology depth ($DEPTH$) and technology breadth ($BREADTH$) are our independent variables, both calculated at the alliance level. Following [34], we measure depth in two steps. First, the "Revealed Technological Advantage" (RTA) of each firm is computed:

$$\mathrm{RTA}_{it} = \frac{P_{it}/\sum_t P_{it}}{\sum_i P_{it}/\sum_{it} P_{it}}$$

Where P is the number of patents held by firm *i* in technology class *t.* The above ratio is the ratio of the share of firm *i* patents in technology class *t*, to the share of all patents falling in that technology class. It accounts for concentration of a firm in a given technology class relative to all firms in the industry. Then, we calculate the coefficient of variation for all the firm's RTA measures, as it follows:

$$\mathrm{depth} = \frac{\sigma_{\mathrm{RTA}}}{\mu_{\mathrm{RTA}}}$$

The 'depth' equation above indicates that a firm's technological depth is high when it has developed a high relative technological advantage in one or few technology classes, whereas a vector of equal RTA values would result in a relatively low measure of depth ([35])

Regarding 'technology classes' or 'subject areas', it is possible that a single patent falls in more than one area, for example in both "Chemistry" and "General & Internal Medicine". With the help of Derwent Innovation Index, we identified a total of 123 technology classes where firms in our sample had patenting activity in, during the three-year period prior to entering their respective alliances. Our calculated measure of depth yielded an average of 6.6 for each alliance, where the alliance with the "technologically-deepest" biotech partner in it had a depth value of 12.08 and the alliance with the "technologically-shallowest" firm in it had a depth value of 2.27.

Technology breadth is the range of knowledge areas that the technology firm has expertise in. For measuring it, we simply count the total number of technology classes in which the firm was granted patents in the 3 years leading up to the alliance [34]. From the total of 148 technology classes that were identified, the technologically-broadest biotech firm obtained a breadth value of 48, while the technologically-narrowest firm obviously got a breadth value equal to 1.

Prior Alliance Experience ($ALLYEXP$): Our moderating variable is biotech firm's prior alliance experience. This is measured as the total number of alliances with all alliance partners that the biotech firm had prior to and including the formation of the alliance with the pharmaceutical firm in question. The total number of prior alliances is coded as an integer ranging from 1 to 24, and the mean number of prior alliances with other firms was 5.35.

Control Variables: While investigating the factors that affect choice of governance, we take into account and control for other variables that can have an impact apart from technological depth and breadth.

Entry Stage of Technology Development ($STAGE$): Past research suggeststhat the bargaining power of the new technology firm increases with the development stage of the product candidate [2]. Therefore, an important control variable in our study is the stage of development of the technology in the alliance. 'Entry Stage of Technology Development' is the development stage of the technology associated with the alliance. Following [10] we identify four main stages: Discovery (coded as 1), Early Clinical (coded as 2), Late Clinical (coded as 3), and Launch (coded as 4).

Relative Size of Agreement ($AGREEMENTSIZE$): When evaluating the possibilities to ally with larger pharma firms, a biotech firm might have to choose between receiving more financial capital through the alliance in exchange for relinquishing some control by giving up equity ownership; or keeping its full control in the form of a non-equity alliance but getting less financial capital. Past research has found that the likelihood of the larger partner receiving equity in its smaller alliance partner increases as the financial capital offered to the smaller partner becomes greater [9]. Hence, the financial capital offered by the larger pharma partner, also called the size of the initial agreement, is an important factor influencing the alliance governance structure.

However, an amount that seems a large incentive for a small firm might not be as appealing to a larger firm. We therefore accounted for the "size of the agreement relative to size of the biotech firm" and operationalized this variable as the ratio of "total up-front payments" (the dollar value of funds provided by the partnering pharmaceutical firm to the biotech firm at time of alliance formation) divided by "the biotech firm's size" (See below).

The biotech firm's size ($SIZE$): Following [6], we control for the firm's size, measured by the total assets of the biotech firm at the time of alliance formation. The average dollar value of total assets for each biotech firm was collected from the Compustat database for the year prior to and the year of the alliance. Due to skewness and the large variability in this measure, we used a log transformation.

The biotech firm's age (AGE): We also controlled for firm's age, which is the number of years elapsed since the founding of the biotechnology firm.

IV. ANALYSIS AND RESULTS

Figure 2 shows the scatterplot of the alliances in our sample, based on the calculated values of technological depth and breadth associated to the biotech partner in the given alliance. From the total of 390 alliances, we first removed 11 observations with outlier 'breadth' values. We then split the remaining set of values for depth and breadth into groups of higher or lower than the average, to plot Figure 2. In fact, this figure corresponds to our earlier grouping of firms into 4 categories, namely: 1) Deep Ocean, 2) Gorge, 3) Lagoon, and 4) Pond firms[1].

It is interesting to note that our earlier expectations hold: First, firms which are both broad and deep are not likely to need alliances. In a total of 390 alliances, we observe only 13 alliances comprising "Deep Ocean" biotech firms. Second, majority of alliances include biotech firms which are labeled as "Gorge" (148 alliances) or "Lagoon" (86 alliances). This demonstrates how our hypotheses on depth and breadth of technological resources are relevant.

There are, however, 132 alliances with biotech firms in "Pond" category. While our study tests the hypotheses on the whole population of firms, we also perform separate analysis limited to each of the four strategic groups and compare the results.

The scatterplot in figure 2 brings even more evidence for our contention that most firms need to be either broad or deep in their technological resources. The arrows show the distribution of firms along the "merely deeper-merely broader" axis. Even when limiting ourselves to the subsample of Lagoon or Pond firm, the contention still holds and biotech firms in alliances are inclined towards the two ends: either being broader than others, or being deeper.

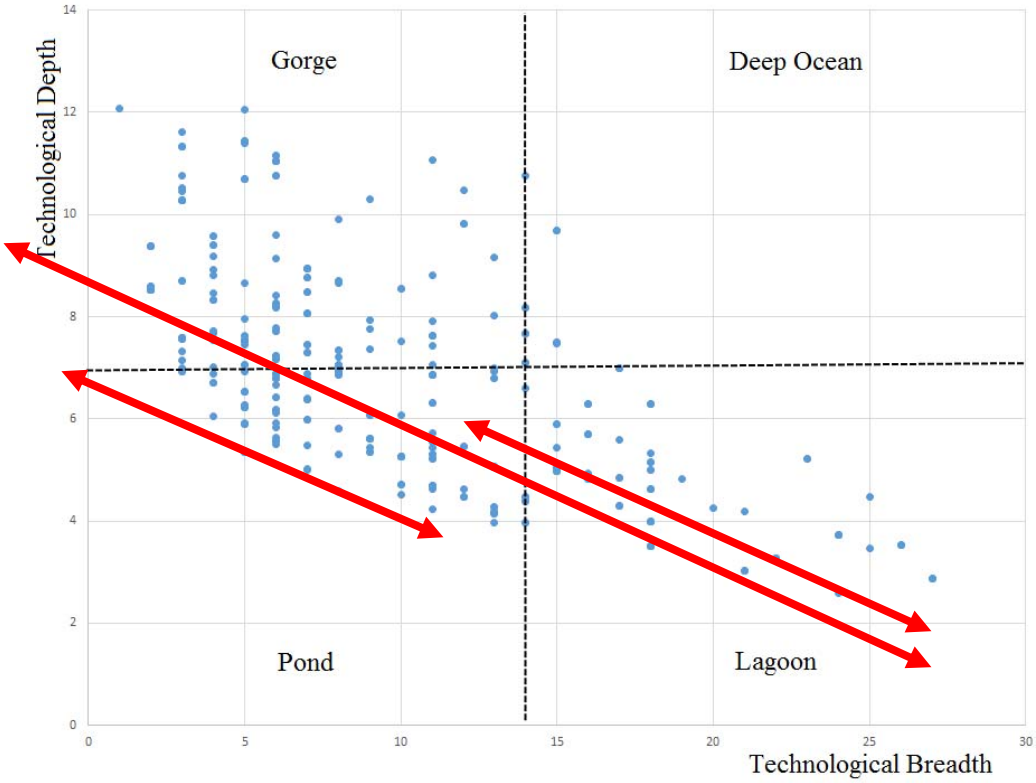

Figure 2: Scatterplot of all alliances in our sample, based on depth and breadth of the biotech partner's technological resources

[1] Clearly the number of dots on the diagram is less than 379, the number of alliances after removing outliers. This is because a dot on the diagram can represent more than one alliance: Many alliances overlap on a single dot as many biotech firms with the same values of depth and breadth entered to several alliances with different Pharma partners.

TABLE 1: DESCRIPTIVE STATISTICS AND CORRELATION

	Mean	S.D.	1	2	3	4	5	6	7	8
1. GOV (E=1, NE=0)	0.24	0.43	1							
2. STAGE	0.35	0.72	0.06	1						
3.AGE	17.86	4.25	0.04	0.36**	1					
4. FIRM SIZE	4.42	1.08	-.28**	0.14**	0.12*	1				
5.AGREEMENT SIZE	12.07	12.82	0.27**	0.29**	-0.1	-0.12	1			
6. DEPTH	6.7	2.17	0.04	0.06	0.25**	-0.30**	0.07	1		
7. BREADTH	10.45	7.27	-.124*	0.02	-0.16**	0.36**	-0.02	-0.71**	1	
8. ALLIANCE EXPERIENCE	5.44	4.17	-.28**	-0.08	-0.05	0.52**	-0.15*	-0.28**	0.32**	1

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

For the Gorge subsample, however, such a distribution is not observed (See figure 2, Gorge quadrant). It appears that if firms are deeper than average (Gorge firms), then they do not look for additional depth or breadth. Perhaps, once they are deep enough, firms seek other strategies, for example, advancing their technology (stage of development of technology, which we control for).

A comparison among the four strategic groups also highlights interesting differences: The average Deep Ocean firm is older than the average firm in any of the other three categories, consistent to our expectation that being both broad and deep means that the firm has taken many years to accumulate expertise and diversify into different fields. We also observe that alliances comprising Deep Ocean firms dealt with technologies that were three times more advanced in their development (later stage technologies) when compared to alliances with firms from the other three groups. Only 14 percent of alliances with Deep Ocean firms included equity arrangements, while the number rises to 30 percent for Pond firms.

Descriptive statistics and correlations for the relevant variables are displayed in Table 1. We observe high correlations between our main explanatory variables namely breadth, depth, and alliance experience. In order to assure that multicollinearity is not an issue, we computed Value Inflation Factors (VIFs) for each pair among the three variables. None of the VIF values reached 3, indicating that we did not encounter multicollinearity.

We observe that equity type of alliance governance is negatively correlated with breadth of technological resources, as well as with alliance experience and size. It is however, positively correlated with the relative size of agreement, in accordance with the common understanding that firms might give up equity ownership in exchange for better financial terms. There is a strong negative correlation between technological depth and breadth, reinforcing our earlier assertion that many firms need to invest exclusively in one of these two dimensions[2]. Among the control variables, stage and age are positively correlated, consistent with the notion that younger firms tend to enter into early stage alliances.

Since our dependent variable, the type of governance structure, is a dichotomous variable (equity versus non-equity), we use binary logistic regression as the method of analysis. We use hierarchical entry of independent variables in all the regressions starting with the control variables in a base model, entering the research variables in the next step and the interaction terms one by one in two subsequent steps; because an interaction effect only exists if the interaction term gives a significant contribution over and above the direct effects of the independent variables. In total, we used four models, and the results of all regressions are illustrated in Table 2.

First, we started with our base model which included only control variables; namely stage of technology, firm's age, firm's size, and relative size of agreement (model 1).

We then added depth, breadth and prior alliance experience to get model 2 as below:

$$GOV(E,NE) = \alpha + (STAGE.\beta 1) + (AGE.\beta 2) + (SIZE.\beta 3) + (AGREEMENTSIZE.\beta 4) + (BREADTH.\beta 5) + (DEPTH.\beta 6) + (ALLYEXP.\beta 7) + e$$

The above model is where we test hypotheses 1 and 2, namely the direct effects of depth and breadth on the choice of governance. Hypotheses 3a and 3b were tested in models 3 and 4, where we entered interaction terms $DEPTH \times ALLYEXP$ and $BREADTH \times ALLYEXP$, respectively.

The control variable log of total assets (SIZE), which controls for the size of the firm, has a negative coefficient and is significant in all the four models. This seems to indicate

[2] As George et. al (2008) put it, our concentration-based depth measure "penalizes firms for dispersion across patent classes", i.e. a broader firm gets lower depth values. While we recognize this, we still keep the measure this way because it compares the concentration of a firm's knowledge base with the concentration of other firms' knowledge bases, regardless of how the size of those knowledge bases compare. This relates to how we conceptualized depth: The relative focus that gives a given firm more leverage than another firm lacking that focus but perhaps having even more resources. Moreover, George et. al (2008) find a correlation of r=0.80, p<0.001 between their own depth measure and the concentration-based measure which is similar to ours.

TABLE 2: LOGISTIC REGRESSION MODELS

Dependent Variable	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
GOVERNANCE (E=1, NE=0)	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***
Constant	0.69	1.32	3.05*	1.81	1.58	1.94	3.60*	1.87
Control variables								
STAGE	0.32	0.27	0.35	0.28	0.42	0.29	0.36	0.29
AGE	0.06	0.05	0.05	0.06	0.07	0.06	0.07	0.06
FIRM SIZE	-0.78***	0.21	-0.72**	0.23	-0.79**	0.24	-0.74**	0.24
AGREEMENT SIZE	0.1***	0.03	0.1***	0.03	0.11***	0.03	0.1***	0.03
Independent Variables								
DEPTH			-0.24*	0.12	-0.01	0.15	-0.26*	0.12
BREADTH			-0.04	0.05	-0.07+	0.05	-0.11*	0.06
ALLIANCE EXPERIENCE			-0.13*	0.07	0.41*	0.23	-0.29*	0.13
Interactions								
DEPTH x ALLIANCE EXPERIENCE					-0.08*	0.04		
BREADTH x ALLIANCE EXPERIENCE							0.02*	0.01
Model								
Block Chi-square	46.06***		7.51*		5.77*		2.55+	
Model Chi-square	46.06***		53.58***		59.34***		56.12***	
Cox and Snell R-squared	0.24		0.27		0.29		0.28	

+ p<0.1, * p<0.05, ** p<0.01,
*** p<0.001. N=390 alliances

that the smaller the biotechnology firm, the greater is the tendency of the firm to give up control to the pharmaceutical firm by entering into an equity alliance. Relative size of agreement also demonstrates a positive coefficient and significant in all the models, which implies the same notion we derived from the correlations table: Biotech firms in alliance face a trade-off between financial gain and control.

Results indicate a significant negative association between depth of the technology firm and equity type of governance for the alliance ($\beta = -0.24, p < 0.05$). That means biotech firms with deeper technological resources retain greater control in the alliance through non-equity arrangements. We thus find support for hypothesis 1. The β coefficient corresponding to breadth is, however, not significant ($\beta = -0.04$). We therefore do not find support for hypothesis 2. Whether a firm is broad or not in its technological resources seems to have no impact on the governance structure of the alliance it forms. However, when we performed the same regression analysis only limited to the firms in each of the four strategic groups, we found some significant impact of technological breadth, which we will elaborate later in section 4.1. The chi-square value for model 2, (Chi-square=7.51) was significant at the 0.01 level, meaning an improvement from our base model to model 2.

Model 3 included alliance experience as a moderator of the relationship between depth and type of governance. We observe a significant negative relationship between interaction term $DEPTH \times ALLYEXP$ and equity type of governance, which lends support to hypothesis 3a ($\beta = -0.08, p < 0.05$). This means that, when they have more prior alliance experience, firms with deeper technological resources tend to engage even less in equity-based alliances. We discuss this interesting finding in the discussions section. Moving from model 2 to model 3, we observed an improvement in the goodness-of-fit as model 3 has a delta Chi-square of 5.77, p<0.05.

Model 4 included alliance experience as a moderator of the relationship between breadth and type of governance. Although breadth did not show a significant direct effect on type of governance, in both of the models with interaction effects (models 3 and 4) it does show significant negative associations with equity type of governance (contrary to what we had hypothesized). Furthermore, we find that the interaction term $BREADTH \times ALLYEXP$ shows a significant positive association with equity type of governance in alliance ($\beta = 0.02, p < 0.05$). Taken together with the statistically-significant regression coefficients obtained for breadth ($\beta = -0.11, p < 0.05$) and alliance experience ($\beta = -0.29, p < 0.05$), we find that contrary to our expectation in hypothesis 3b, alliance experience combined with breadth led to more, not less hierarchical forms of government. Our results of the analysis limited to each strategic group complement these general findings about both the direct effect of technological breadth as well as its interactive effect (breadth with alliance experience) on the choice of governance. Below we first present those results and then discuss all our findings taken together.

A. Analysis in the Four Strategic Groups

As we mentioned earlier, in addition to testing the hypotheses in the total population of alliances (N=390), we repeat the same statistical analysis (models 1 to 4) in each subsample corresponding to each strategic group. Most noteworthy results were obtained from analysis in Lagoon group (n=97) and Gorge group (n=148) which are presented in tables 3 and 4, respectively.

Unlike Gorge and Lagoon subsamples, regression analysis in Pond (n=132) group did not yield any significant results to

add anything new to our understanding from the results in the overall sample (we did not include the table because of space limitation). In Deep Ocean (n=13) group the number of observations was too little to be enabling us to infer meaningful results.

It is interesting to note that while in the overall sample we did not find support for hypothesis 2 (relationship between technological breadth to type of governance), we do find such a support when considering only the population of Lagoon firms:Our breadth measure shows a significant positive association with equity type of governance ($\beta = 0.04, p < 0.05$. See Table 3, model 2). Yet more interesting is observing that in Gorge subsample, the direction of this effect is reversed ($\beta = -0.34, p < 0.05$. See Table 4, model 2), contrary to hypothesis 2. We discuss these findings in section 5

V. DISCUSSION AND CONCLUSIONS

Previous research has explained how knowledge and technological resources are important factors for the small technology firm's success in retaining control in alliances [9]. Our research scrutinizes these technological resources and investigates the effect of their depth and breadth on the ability of the small technology firm to maintain full equity rights while allying with a larger firm. Moreover, we explore the role of prior alliance experience in this regard.

TABLE 3: LOGISTIC REGRESSION MODELS- LAGOON SUBSAMPLE, N=97

Dependent Variable	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
GOVERNANCE (E=1, NE=0)	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***
Constant	-3.42	2.74	-11.95*	6.32	-18.99*	9.64	-10.10+	6.72
Control variables								
STAGE	0.27	0.70	0.25	0.75	-0.17	0.81	0.08	0.77
AGE	0.21	0.16	0.24	0.20	0.25	0.26	0.25	0.22
FIRM SIZE	-0.48	0.44	-0.78	0.61	-0.71	0.73	-0.69	0.64
AGREEMENT SIZE	0.10*	0.06	0.10*	0.06	0.11*	0.06	0.10*	0.06
Independent Variables								
DEPTH			0.57	0.55	2.05+	1.35	0.63	0.57
BREADTH			0.40*	0.24	0.37+	0.25	0.26	0.30
ALLIANCE EXPERIENCE			-0.15	0.23	0.94	0.87	-0.69	0.79
Interactions								
DEPTH x ALLIANCE EXPERIENCE					-0.24	0.18		
BREADTH x ALLIANCE EXPERIENCE							0.03	0.04
Model								
Block Chi-square		10.60*		3.90		2.33+		0.50
Model Chi-square		10.60*		14.50*		16.83*		15.00*
Cox and Snell R-squared		0.23		0.30		0.34		0.31

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

TABLE 4: LOGISTIC REGRESSION MODELS- GORGE SUBSAMPLE, N=148

Dependent Variable	**Model 1**		**Model 2**		**Model 3**		**Model 4**	
GOVERNANCE (E=1, NE=0)	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***	**Beta**	***s.e.***
Constant	3.49	2.60	12.35*	4.94	12.73*	5.44	12.06*	5.03
Control variables								
STAGE	0.47	0.48	1.14*	0.66	1.13*	0.66	1.20*	0.69
AGE	0.09	0.09	0.16	0.11	0.15	0.11	0.16	0.11
FIRM SIZE	-1.70**	0.52	-2.00**	0.69	-1.99**	0.70	-1.99**	0.70
AGREEMENT SIZE	0.09*	0.04	0.13*	0.06	0.13*	0.06	0.14*	0.06
Independent Variables								
DEPTH			-0.74*	0.31	-0.78*	0.40	-0.75*	0.32
BREADTH			-0.34*	0.19	-0.34*	0.20	-0.29	0.26
ALLIANCE EXPERIENCE			-0.38*	0.21	-0.54	1.02	-0.26	0.42
Interactions								
DEPTH x ALLIANCE EXPERIENCE					0.02	0.11		
BREADTH x ALLIANCE EXPERIENCE							-0.02	0.08
Model								
Block Chi-square		26.44***		14.41**		0.03		0.10
Model Chi-square		26.44***		40.85***		40.88***		40.95***
Cox and Snell R-squared		0.31		0.40		0.44		0.41

+ p<0.1, * p<0.05, ** p<0.01, *** p<0.001

Consistent with our first hypothesis we confirm that the deeper a firm's technology and knowledge base, the less likely it will be to form equity alliances. This is important because the small partner's knowledge or technology is a main resource involved in the alliance formation and also the core of the biotechnology firm's existence [6]. Our findings are consistent with the general view of biotechnology firms as science-based firms specialized in one or few technology areas that bring their specialized knowledge to their alliances with more technologically broad-based pharmaceuticals. The deep knowledge held by the smaller biotechnology partner seems to perfectly complement the broad-based capabilities of the larger pharma partner. We find that 'the deeper the technological resources of the biotech partner in the alliance, the less the propensity to use equity in governing that alliance'. This could point to two facts: First, technologically-deeper biotech firms seem as more appealing partners to the pharmaceutical firm, such that they can enjoy an improved level of bargaining power when negotiating the alliance terms and leverage their technological depth to give-up the least amount of control rights to the financier of their R&D project. Second, pharmaceutical firms attribute more trust and confidence to the technologically-deep biotech partner, as these firms seem to be more capable of accomplishing the set goals of the project in alliance. The pharma partner might therefore insist less on taking an equity stake and obtaining a seat at the table, so to speak, because it trusts that the biotechnology partner has enough expertise to govern the alliance in the direction that meets the benefits of both partners.

Our results also suggest that the likelihood of the biotech firm to establish a non-equity alliance with the larger partner increases as the biotech firm gains more alliance experience. First, consistent with previous research (e.g. [9]), we found that as the biotech firm accrues more alliance experience, it is more capable of entering a non-equity alliance with the pharma partner (We did not form this as a hypotheses, since we were not interested in the direct effect of alliance experience on governance, but in its interactive effects with each of the depth and breadth dimensions of technological resources). Moreover, as we had hypothesized, we found that technologically-deep biotech firms that benefited from more alliance experience, performed better in retaining equity rights in their downstream alliances, comparing to those with less prior experience. It is not only depth of technology that signals capability of the biotech firm to its pharma partner, but the accumulation of deep technological knowledge together with alliance experience. These accumulated expertise points to both the technical capability and alliance management capability of the smaller partner, and leads to greater amounts of trust and confidence being bestowed upon it from the side of the larger pharma firm.

As to the impact of technological breadth on the type of governance, our analysis in the large sample of all alliances did not yield any significant result. Furthermore, contrary to our expectation, we found that the biotech firm's alliance experience combined with its technological breadth led to a more, not less, hierarchical form of government. The fact that alliance experience moderated the depth-governance and breadth-governance relationships in opposing ways, offers an avenue for further research. It could be that the broader firms have less fear of opportunistic behavior from their pharma partners, as they accrue more alliance experience, and therefore they agree to form an equity-based alliance. It is noteworthy that many of the biotech firms in our sample had previous ties with the same pharma partner. Therefore, our results could be pointing to the fact that these repeated ties leads the biotech firm to build more trust and have less fear of giving some control to the larger partner by selling equity. It could be that broader firms recognize that they do not have leverage similar to that of deeper firms in order to bargain for forming a non-equity alliance, and therefore, as they gain more alliance experience, they learn that it is better to go for more financial capital in exchange for giving away equity rights to the pharma partner. However, due to data limitation, our research cannot confirm this. We'll further discuss this issue in section 5.2.

Finally, as we performed the same regression analysis in each of the four strategic groups, we found some interesting results. While we did not find the expected positive association between technological breadth and equity type of governance in our total population, we found such a relationship when limiting our analysis to Lagoon sub-sample, i.e. firms that are broad but not deep. When all the firms are relatively broad and relatively shallow in their technological resources, the breadth dimension of the biotech firm's technology seems to strongly affect the type of governance towards an equity-based one. This could point to the fact that the broader firm has less fear over opportunistic behavior from the side of the pharma partner, as it has diversified its knowledge base over a broad range of areas and is less concerned about relinquishing control in a partnerships that deals only with a few of its areas of expertise.

Moreover, in the Gorge sub-sample, i.e. among firms that are technologically deep but not broad when compared to other firms, we found a negative association between technological breadth and equity type of governance. This means that when the technology firm is deep enough in its technological resources, i.e. the larger partner is assured about its specialized expertise, then not only the breadth dimension of the firm's technology is not detrimental, but it is also beneficial in helping the deep firm to retain control right and form a non-equity alliance.

A. Contributions to the literature

Our study sheds light on the less known characteristics of technology firms and proves them to have an impact on the governance of the alliances made by these firms. We highlight the importance of distinguishing depth and breadth of technological knowledge when studying alliance relationships. Past research has found that technical capital,

knowledge base or technical competence, may be a biotechnology firm's major source of leverage when forming an alliance with a resource-rich pharmaceutical company (e.g. [3] ; [9]; [10]). We build up upon and add to these research by suggesting that the depth and the breadth dimension of these technological resources can have differing impacts in the alliance relationship. Therefore a biotechnology firm's source of leverage can be decomposed into "depth" and "breadth" dimensions and be further scrutinized as these dimensions seem to separately influence alliance-level measures such as alliance governance.

Making the distinction between depth and breadth of technological knowledge can also help explain some contradicting findings in the biopharma alliance literature, for example regarding the impact of technological resources of the smaller biotechnology firm on the amount of financial capital it acquires from the pharma partner upon entering an alliance (e.g. [10]; [32]; [7])

B. Limitations and Future Lines of Research

Despite its contributions, our study has a number of limitations which offer avenues for future research: First, as we formed our dependent variable as a binary (equity versus non-equity alliance), our study does not distinguish how much equity the alliance partner gives up in an equity alliance. If the amount is very small, it may have different implications than if it's a large amount of equity rights given up in the alliance.

Second, we solely focus on US alliances between biotech firms as technology providers and pharma firms as clients. Results might not be generalizable to other countries and other types of vertical alliances. A future line of research could study the phenomenon in a broader settings with more heterogeneity among the technology firms.

Third, as we saw earlier when discussing our findings, we got mixing results as to the impact of the biotech firm's prior alliance experience and how this experience moderates the relationship between knowledge dimensions and alliance governance. Due to data limitation, we did not distinguish between alliances that a biotechnology firm forms with a repeating partner and those with a new one. By making this distinction, future research can explain the mixing findings of our study regarding the moderating role of prior alliance experience. As we elaborated on credibility and trust as a mechanism that leads to less contractual complexity when firms ally, we saw that repeating ties and new ties can have opposing impacts on choice of governance. Several new ties that the focal biotech firm has made in the past, enhances its credibility and reputation in the marketplace, and therefore can have a positive impact on its effort to form non-equity alliances. On the other hand, repeated ties with the same partner can help a biotech firm desperate for financial capital to easier trust that pharma partner in an equity-based alliance and obtain the needed capital. Therefore, in such situations repeated ties with the same partner can lead to occurrence of equity type of alliance.

Finally, there seems to be a survivor-like bias in our sample. The firms in our sample are older and have had more previous alliances than the firms that are not included in the sample. This bias may mean that our results regarding the importance of prior alliance experience of the biotech firm may be somewhat inflated; it could be that we are not capturing a phenomenon regarding those firms with less alliance experience. This bias may also explain the prevalence of non-equity arrangements in the studysample.

C. Implications for Practice

Managers of new technology firms must make sure that their knowledge resources are both effectively and efficiently developed and exploited. Knowledge and technological resources are the core of these firms' existence and often the main resources involved in alliances, especially with downstream partners [6].

Managers of new biotech firms need to recognize the differing potential roles of knowledge depth and breadth when adopting their knowledge strategy. Developing in-depth knowledge and expertise can further lead to patents granted to the firm. Patents are a sign of the firm's success and accomplishment ([7]), helping it in attracting financial capital from venture capitals and/or alliance partners, and, as explained by our research, also helping the firm to retain control in the alliance by not giving away equity rights. We believe that the empirical results of this study can shed light on the less known characteristics of technology resources that are important for managers of science-based firms when adopting their knowledge strategy. With limited resources, small technology-based firms need to invest only in the right type and right dimension of technological knowledge: the one that brings them highest returns and most leverage in their inter-firm linkages.

REFERENCES

[1] Adler, P. S., & Kwon, S. W. (2002). Social capital: Prospects for a new concept. Academy of management review, 27(1), 17-40.

[2] Aghion, P., & Tirole, J. ,(1994). The management of innovation. The Quarterly Journal of Economics, 1185-1209.

[3] Ahuja, G. (2000). The duality of collaboration: inducements and opportunities in the formation of interfirm linkages. Strategic Management Journal, 21: 317–343.

[4] Bierly, P., & Chakrabarti, A. (1996). Generic knowledge strategies in the US pharmaceutical industry. Strategic Management Journal, 17(S2), 123-135.

[5] Carayannopoulos S. and Auster E.R, (2010). External knowledge sourcing in biotechnology through acquisition versus alliance: A KBV approach

[6] Coombs, J. E., & Deeds, D. L. ,(2000). International alliances as sources of capital: Evidence from the biotechnology industry. The journal of high technology management research, 11(2), 235-253.

[7] Coombs, J. E., Mudambi, R. & Deeds, D. L., (2006). An examination of the investments in U.S. biotechnology firms by foreign and domestic corporate partners. Journal of Business Venturing, 21: 405–28.

[8] Deeds, D. L., Decarolis,D. & Coombs, J. E., (1997). The impact of firm-specific capabilities on the amount of capital raised in initial public offering: evidence from the biotechnology industry'. Journal of Business Venturing, 12: 31–46.

[9] Dunne, D. D., Gopalakrishnan, S., & Scillitoe, J. L. (2009). An empirical study of the impact of firm resources on alliance governance structures. Journal of Engineering and Technology Management, 26(3), 181-195.
[10] Gopalakrishnan S., Scillitoe J.L., Santoro M.D., (2008). Tapping Deep Pockets: The Role of Resources and Social Capital on Financial Capital Acquisition by Biotechnology Firms in Biotech–Pharma Alliances. Journal of Management Studies 45, 1354-1376
[11] Grant, R. (1996). Toward a knowledge-based theory of the firm, Strategic Management Journal, 17: 109-122
[12] Grant, R., & Baden-Fuller, C. (2004). A knowledge accessing theory of strategic alliances. Journal of management studies, 41(1), 61-84.
[13] Gulati, R. (1995). Does familiarity breed trust? The implications of repeated ties for contractual choice in alliances. Academy of management journal, 38(1), 85-112.
[14] Gulati, R., & Singh, H. (1998). The architecture of cooperation: Managing coordination costs and appropriation concerns in strategic alliances. Administrative science quarterly, 781-814.
[15] Haeussler, C. & Patzelt, H. (2008). Strategic alliances and product pevelopment in new technology firms: The moderating effect of technological capabilities. Frontiers of Entrepreneurship Research, 28: 1-15
[16] Hagedoorn, J. (2002). Inter-firm R&D partnerships: An overview of major trends and patterns since 1960. Research Policy, 31(4), 477-492.
[17] Hamel, G., & Prahalad, C. K. (1994). Competing for the futureHarvard business school press. Boston, MA,
[18] Hoang, H., & Rothaermel, F. T. (2005). The effect of general and partner-specific alliance experience on joint R&D project performance. Academy of Management Journal, 48(2), 332-345.
[19] Lerner, J., & Merges, R. P. ,(1998). The control of technology alliances: An empirical analysis of the biotechnology industry. The Journal of Industrial Economics, 46(2), 125-156.
[20] Lerner, J., Shane, H., & Tsai, A. ,(2003). Do equity financing cycles matter? Evidence from biotechnology alliances. Journal of Financial Economics, 67(3), 411-446.
[21] Levitt, B. and J.G. March (1988). 'Organizational Learning,' Annual review of Sociology, 14: [319–340.
[22] Mason, R., & Drakeman, D. L. (2014). Comment on "fishing for sharks: Partner selection in biopharmaceutical R&D alliances" by diestre and rajagopalan. Strategic Management Journal, 35(10), 1564–1565. Retrieved from http://onlinelibrary.wiley.com/doi/10.1002/smj.2177/full
[23] McGill, J. P., & Santoro, M. D. (2009). Alliance portfolios and patent output: The case of biotechnology alliances. Engineering Management, IEEE Transactions on, 56(3), 388-401.
[24] Nielsen, B. B. (2005). The role of knowledge embeddedness in the creation of synergies in strategic alliances. Journal of Business Research, 58(9), 1194-1204.
[25] Nielsen, B. B., & Nielsen, S. (2009). Learning and innovation in international strategic alliances: An empirical test of the role of trust and tacitness.Journal of Management Studies, 46(6), 1031-1056.
[26] Osborn, R. N., & Baughn, C. C. ,(1990). Forms of inter-organizational governance for multinational alliances. Academy of Management journal, 33(3), 503-519.
[27] Oxley, J. E., & Sampson, R. C. (2004). The scope and governance of international R&D alliances.
[28] Pateli. (2009). Decision making on governance of strategic technology alliances. Management Decision, 47(2), 246-270.
[29] Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. Administrative science quarterly, 116-145.
[30] Shan, W., Walker, G., & Kogut, B. (1994). Interfirm cooperation and start-up innovaton in the biotechnology industry. Strategic Management Journal, 15, 387-394.
[31] Simonin, B. L. (1997). The importance of collaborative know-how: An empirical test of the learning organization. Academy of management Journal, 40(5), 1150-1174.
[32] Stuart, T. E., Hoang, H. & Hybels, R. C. (1999). Interorganizational endorsements and the performance of entrepreneurial ventures. Administrative Science Quarterly, 44: 315–49.
[33] Walker, R. D. (1995). Patents as scientific and technical literature Scarecrow Press.
[34] Zhang, J., Baden-Fuller, C., & Mangematin, V. (2007). Technological knowledge base, R&D organization structure and alliance formation: Evidence from the biopharmaceutical industry. Research Policy, 36(4), 515-528.
[35] Zhang, J., & Baden-Fuller, C. (2010). The influence of technological knowledge base and organizational structure on technology collaboration.Journal of Management Studies, 47(4), 679-704.